AD NUMBER
AD473580
LIMITATION CHANGES
TO: **Approved for public release; distribution is unlimited.**
FROM: **Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; JUL 1965. Other requests shall be referred to Office of Naval Research, 875 North Randolph Street, Arlington, VA 22203-1995.**
AUTHORITY
ONR ltr, 25 Jun 1971

SECURITY MARKING

The classified or limited status of this report applies to each page, unless otherwise marked.
Separate page printouts MUST be marked accordingly.

THIS DOCUMENT CONTAINS INFORMATION AFFECTING THE NATIONAL DEFENSE OF THE UNITED STATES WITHIN THE MEANING OF THE ESPIONAGE LAWS, TITLE 18, U.S.C., SECTIONS 793 AND 794. THE TRANSMISSION OR THE REVELATION OF ITS CONTENTS IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PROHIBITED BY LAW.

The Role of Cognitive Factors in the Recognition of Ambiguous Visual Stimuli

Prepared by
JOHN R. FREDERIKSEN

JULY 1965

Educational Testing Service
Research Bulletin (RB-65-23)

and

ONR Technical Report

Prepared in connection with research done under
Office of Naval Research Contract Nonr 1858-(15),
Project Designation NR 150-088, and
National Science Foundation Grant G-22889
with Princeton University, Princeton, New Jersey
Project on: "Mathematical Techniques in Psychology"
Principal Investigator: HAROLD GULLIKSEN

THE ROLE OF COGNITIVE FACTORS IN THE RECOGNITION OF AMBIGUOUS VISUAL STIMULI

Prepared by
JOHN R. FREDERIKSEN

JULY 1965

Educational Testing Service
Research Bulletin (RB-65-23)

and

ONR Technical Report

Prepared in connection with research done under
Office of Naval Research Contract Nonr 1858-(15),
Project Designation NR 150-088, and
National Science Foundation Grant G-22889
with Princeton University, Princeton, New Jersey
Project on: "Mathematical Techniques in Psychology"
Principal Investigator: HAROLD GULLIKSEN

THE ROLE OF COGNITIVE FACTORS IN THE RECOGNITION

OF AMBIGUOUS VISUAL STIMULI

Abstract

The effect of five cognitive abilities on the recognition of out-of-focus pictures was investigated using a factor extension procedure which is sensitive to differences among the slides in the abilities they require for recognition. In addition to recognition point measures, the subjects received scores reflecting their rate of hypothesis formation during the early stages of blur. The results indicated that the pictures did not all require the same cognitive abilities for their recognition. Nevertheless, some general effects of the cognitive abilities on slide recognition, which were independent of the particular picture, were also noticed. It was found that the ability to visualize (to transform the image of a spatial pattern into other visual arrangements) was negatively associated with early slide recognition, while Speed of Closure (the ability to unify an apparently disparate perceptual field into a single percept) was positively related to early recognition. It was also observed that visualizers tended to make fewer guesses about the blurred pictures than did nonvisualizers, while people who were high in Speed of Closure produced many initial hypotheses. It was found that the chances of recognizing early were greater for subjects who produced many initial hypotheses than for subjects who had few initial ideas.

These results cast doubt upon a theory of interference in visual recognition which states that early erroneous hypotheses inhibit recognition. It was suggested that hypothesis testing is not sequential and that the outcome of perceptual testing is a "confirmed-not confirmed" distinction, rather than an "accepted-rejected" one. The results were summarized in a

post hoc computer simulation type of model which also incorporated the hypothesis that interference in perceptual recognition can be accounted for by the tendency for visualization to predominate over the formation and testing of hypotheses during conditions of extreme ambiguity or blur.

Finally, the status of Speed of Closure as a separate, unitary cognitive ability was questioned. On the basis of the great similarity between the relations of recognition point and Speed of Closure to the other variables employed in this study, it was suggested that tests for Speed of Closure may potentially involve the same interference effects which are observed in experiments in perceptual recognition.

The Role of Cognitive Factors in the Recognition
of Ambiguous Visual Stimuli

Under normal circumstances people perceive and identify familiar complex objects almost instantaneously. However, when the stimulus is obscured and made ambiguous by being thrown out of focus visual recognition is impaired. An interesting phenomenon is that an initial exposure to such an out-of-focus visual stimulus which is misinterpreted interferes with subsequent recognition of the stimulus object as it is brought slowly into focus. Subjects who have been exposed to a highly blurred image and who have attempted to recognize that image without being given any feedback about the correctness of their conjectures, finally recognize the picture at a point of focus which is nearer full focus than the normal recognition point for subjects who have escaped seeing the early blurred image.

This interference effect of early hypotheses upon subsequent recognition was first demonstrated by Galloway (1946) and was later replicated by Wyatt and Campbell (1951) using instructions which insured that the subjects were attempting to perceive the objects veridically. These investigators interpreted their result as demonstrating "a reduction in the adequacy of perception due to previous unverified hypothesizing or guessing." Bruner and Potter (1964) explored the separate effects of two previously confounded variables: exposure time and focus range of viewing. Using an analysis of variance design, they confirmed the finding that previous exposure to a very blurred image interferes with recognition. They also found that when the initial blur was less prolonged, the degree of interference with later recognition was increased. Bruner and his associates have gone on to employ the slide recognition experiment in the study of mental defectives and children (e.g., Potter, 1962).

The interference phenomenon has been demonstrated using auditory stimuli as well. Blake and Vanderplas (1950) demonstrated that nonveridical recognition of a word presented at sub-threshold loudness elevates the intensity levels necessary to obtain correct recognition of the word. Again, it appears that hypothesizing about the character of an ambiguous stimulus array with no knowledge of correctness or incorrectness interferes with its subsequent recognition when the ambiguity is reduced.

Bruner and Potter, in their study, were interested in finding out if their subjects were consistently good or bad recognizers. They reported a Kendall measure of concordance of .116 for their 13 subjects and became pessimistic about the existence of a general recognition ability. However, assuming individual differences in the cognitive abilities of the slide observers, such a low degree of intrasubject consistency could be accounted for if the pictures varied in terms of the cognitive abilities required for recognition.

Previous attempts to study the cognitive processes in perceptual recognition have involved the study of protocols of subjects who were asked to verbalize their thoughts while attempting to recognize ambiguous pictures (Davison, 1964). The intent is to identify recurrent trends of thought or strategies for problem solution. The difficulty with such a procedure is that there is no way to verify the interpretations of the protocols.

If consistent individual differences are present, it would be possible, instead, to study the relation of perceptual recognition to other cognitive perceptual variables. An appropriate statistical technique would be some form of multiple regression analysis, since a clear distinction is drawn between dependent and independent variables (Bechtoldt, 1962). Some possible predictor variables have been provided by factor analytic studies of cognitive abilities.

Factor analysis is a particularly appropriate method for studying cognition. By factoring data from several tests which require the same mental ability with respect to different test contents, and by partitioning the total variance of the tests into ability and test specific components, an ability measure relatively independent of test content is achieved. An ability so measured can be defined in more abstract terms and possesses, as a consequence, more general theoretical usefulness than does a measure derived from a single test. It can serve in the analysis of such complex behaviors as perceptual recognition.

A number of cognitive abilities of a perceptual nature seem related to perceptual recognition. Five of these were selected from the 24 factors reviewed and described by French (1951) and French, Ekstrom, and Price (1963). The selection of factors for inclusion in the test battery was based upon their relevance to some preliminary notions about the recognition process. The following five processes (factors) were selected for the present study: the scanning of a spatial field, the manipulating of an image of a spatial pattern, the perception of spatial patterns, the ignoring of perceptual distractions, and the unifying of a disparate perceptual field. No specific hypotheses were offered about the role of each ability in slide recognition. The study was designed, however, to provide the answers to some specific questions:

(1) Are pictures unidimensional with respect to the cognitive abilities required for their recognition under conditions of ambiguity? It would seem

that they are not, considering Bruner's reported low measure of subject concordance.

(2) Which of the five abilities represented are important in perceptual recognition? Of those that are relevant, which contribute to early recognition and which, if any, hinder recognition?

(3) Does the formation of many hypotheses under conditions of stimulus ambiguity contribute to efficient slide recognition or does it interfere with subsequent recognition? Blake and Vanderplas (1950) suggest that unconfirmed hypothesizing interferes with recognition.

Any relationships discovered between perceptual recognition and cognitive abilities will provide information about the abilities themselves in addition to facilitating the analysis of the recognition process. This means that, by the same rationale which enables the factor analyists to define operationally abstract mental abilities in terms of the similarities in tasks required in a number of tests, one's conception of an ability can be modified by his increasing knowledge of the role it plays in other complex tasks.

Method

Procedure

Twenty Kodachrome color slides were selected from the set assembled by Bruner and Potter. These slides were photographs of real objects. Copies of these slides were made at each of a number of different stages of focus. In a previous scaling study (Frederiksen, 1963) a subjective scale of focus had been developed using two scaling procedures: category ratings and a method of sorting. Both of these methods required the subject to partition the interval between two anchors, full focus and maximum blur (a nearly homogenous field)--a procedure appropriate for the focus continuum. A plot of category ratings against focus (linear distance a projector lens is moved forward from the point of full focus) was made and found to agree in form with a similar plot using the sorting data. The category rating scale was divided into 14 subjectively equal focus intervals by selecting 15 scale values. Focus settings corresponding to each of these scale values were calculated from a curve fitted to the data points.

The fitted curve was closely approximated by a logarithmic function. Let f equal the number of 64ths of an inch forward from full focus that the projection lens is to be moved, and let s equal the number of the focus stage (where 1 = full focus and 15 = full blur or 14 subjectively equal focus intervals from full focus). Then the approximate focus of each blurred slide is given by

$$f \doteq 3.12 \text{ antilog}_{10} (.09\, s - .33) + .94$$

or

$$s \doteq 11.11 \log_{10} (.32\, f - .30) + 3.66 \quad .$$

The slides were reproduced by taking pictures of their projected images at all 15 stages of focus. Projector lens movements were measured with a trisquare to an accuracy better than 1/100 of an inch. The slides were projected onto a grainless screen by a Kodak Cavalcade Projector equipped with an Ektanar five inch lens. The new set of slides was photographed with a single lens reflex camera through a 135 mm. telephoto lens, using Kodachrome X film. The camera was located adjacent to the projector and, since the screen was located 25 feet away, parallax distortions were minimized. The resulting 300 slides were stored in circular slide trays and could be consecutively presented to groups of subjects with ease.

The slides were presented to the subjects in the order indicated in Tables 4, 5, and 6. Starting with the farthest out of focus, each stage of focus was presented for 10 seconds followed by a 15 second period during which subjects wrote their guesses about what the slide depicted. In all, 6 1/4 minutes were spent covering the 15 focus stages for each of the 20 slides. The viewing time used was selected to maximize the interference effects of exposure to ambiguous material. Since in Bruner and Potter's study (1964) the effects of focal range were maximally apparent at their longest total viewing time of 122 seconds, a total viewing time of 150 seconds per picture was selected for this study. During the 15 second interval between stages of focus, the subjects were required to jot down their ideas concerning the blurred picture. They were also required to circle a number (0 - 10) indicating their degree of certainty about their interpretation of the slide. The actual instructions which the subjects received are reproduced in Appendix B, along with a sample page from the response booklet.

The first testing session lasted about two and one half hours, during which time all 20 slides were brought slowly into focus. A short break was permitted after each group of five pictures had been shown in all 15 stages of focus.

The second testing session, held one week later, was devoted to the administration of 13 factor tests representing five perceptual cognitive abilities. The five factors which were chosen are listed in Table 1 along with descriptions of the mental operations they represent and the names of the tests used in their measurement. Spatial Scanning, Flexibility of Closure, and Visualization were represented by three tests each, while Spatial Orientation and Speed of Closure were each represented by two tests.

Table 1

Marker Tests for Cognitive Ability Factors

Factor	Description of Ability[a]	Marker Tests	Mean	Standard Deviation	Reliability[b]	Communality Estimate	Index of Factorization[c]
Spatial Scanning	Speed in visually exploring a wide or complicated spatial field.	Choosing a Path (2)	15.52	6.95	.77	.69	90%
		Map Planning (10)	25.02	6.12	.79	.71	90%
		Maze Tracing Speed (11)	30.28	8.28	.94	.58	61%
Flexibility of Closure	The ability to keep one or more definite configurations in mind so as to make identification in spite of perceptual distractions.	Copying (4)	35.02	10.87	.82	.66	80%
		Hidden Figures (8)	13.98	6.21	.72	.21	29%
		Hidden Patterns (9)	87.00	18.93	.87	.67	77%
Visualization	The ability to manipulate or transform the image of spatial patterns into other visual arrangements.	Form Board (6)	124.83	38.30	.81	.81	100%
		Paper Folding (12)	13.78	4.52	.84	.62	74%
		Surface Development (13)	43.56	15.14	.90	.70	78%
Spatial Orientation	The ability to perceive spatial patterns or to maintain orientation with respect to objects in space.	Card Rotations (1)	148.59	35.69	.80	.58	73%
		Cube Comparisons (5)	22.74	9.37	.84	.69	82%
Speed of Closure	The ability to unify an apparently disparate perceptual field into a single percept.	Concealed Words (3)	25.91	5.26	.71	.33	46%
		Gestalt Completion (7)	17.20	2.54	.69	.25	36%

[a]Factor descriptions are taken from French et al. (1963).

[b]Reliabilities have been corrected for double-length using the Spearman-Brown formula.

[c]The index of factorization is equal to the communality divided by the reliability, and expressed as a percentage.

The parenthetical numbers following the test names in Table 1 indicate the order in which the tests were given. Detailed descriptions of the tests are given in French et al. (1963). The testing session lasted three hours, including two short breaks.

Subjects

The subjects were 46 male and female college undergraduates or recent graduates who were either enrolled at Princeton University or were employees of Educational Testing Service. Data were collected in two pairs of sessions, one in May and the other in July.

Scoring Procedures

The factor tests were scored according to the standard procedures described in the test kit manual (French et al., 1963). Each test was administered in two separately timed parts, so that reliabilities could be computed.

The subjects' slide recognition protocols were scored in three ways: each subject received a score for each picture representing his recognition point, a second score representing the number of early hypotheses made while the picture was far out of focus, and a third score reflecting his degree of confidence about his early hypotheses.

The recognition point was defined as that stage of focus at which a criterion word or phrase (distinct for each slide) was first mentioned with no subsequent return to an incorrect hypothesis. The criteria for recognition are listed for each slide in Tables 4 and 5. These criteria were applied literally, with no "interpretation" of the subject's comments. If a subject failed to write down the criterion word or phrase, he was given a score of 16, which meant that he never recognized the slide. The scores therefore ran from 1 (immediate recognition at the first focus stage) to 15 (recognition only at full focus) and then 16 (no recognition at all).

The number of early hypotheses was defined as the total number of different hypotheses or ideas written during the first four stages of focus. Two ideas were considered "different" if (1) they were totally incompatible ideas, (^) something new was added to a previous idea so as to modify it, or (3) something previously written was declared wrong, while retaining some aspects of the previous ideas. The scorers were asked to note any cases of doubt in applying these scoring rules. Scoring questions arose in only 37 cases out of the total of 920 subject-slide pairs.

The confidence rating was defined as the sum of the ratings circled by the subject during the first four stages of focus.

It should be pointed out that the two scores, recognition point and number of hypotheses, are not entirely independent. If the subject recognizes a slide before the fourth stage of focus, he clearly will write down fewer ideas and be less likely to have a high number of early hypotheses. However, only 20 out of a total of 920 recognition points obtained occurred before the fourth stage of focus. Nevertheless, we must keep in mind that a slight positive correlation between the recognition points and the numbers of early hypotheses can be attributed to the scoring definitions involved. Similarly, a slight negative correlation between the recognition points and the confidence ratings can also be attributed to the scoring method.

Analytical Procedure

The analytical procedure is described in detail in Appendix A. The analysis began with a factor analysis of the cognitive test data, with the purpose of obtaining measures of the five cognitive variables. The principal components factors were first obtained, using an iterative solution for communalities. The first five principal components factors were then rctated analytically according to the equamax criterion, and the rotated factors were tentatively identified. The equamax factors were then rotated obliquely to a position which caused the variables' loadings on the factors to approximate hypothesized values (Hurley & Cattell, 1962). A variable's hypothesized factor loadings were either zero or one: zero on all factors except the one the test was designed to measure, and one on that factor. Further graphic touch-up rotations were made in order to allow one variable (Map Planning) to load on several factors, and the final transformation matrix for the rotations from the equamax solution was recorded, as well as the intercorrelations among the factors.

Having obtained measurements for the individuals on each of the cognitive abilities using the method for computing factor scores described in Appendix A, a factor extension precedure was used to find the loadings of the criterion variables on each of the factors. The extension or criterion variables were the recognition points, numbers of early hypotheses, and confidence scores for each of the 20 slides. The magnitude and direction of the extension loadings indicate how performance on each slide is related to the five cognitive factor variables. If a slide's loadings are large, then a subject's scores on that slide can be approximated by a linear combination of his factor (ability) scores. This is the best prediction of recognition performance taking into account slide differences.

To ascertain how well the cognitive factors can account for slide recognition without taking into account lack of unidimensionality among the slides, a two-way multivariate analysis of variance (Jones, 1960) was employed. Subjects were trichotomized on the basis of their average slide recognition scores (average over slides) and on the basis of their average number of early hypotheses. The results of this test provide a statistical clue to the importance of the cognitive factors in perceptual recognition.

Results

The Factor Analysis

Descriptive statistics of the factor tests are given in Table 1. The four tests with reliabilities below .80 were Choosing a Path, Map Planning, Hidden Figures, and Concealed Words. The factors Flexibility of Closure, Visualization, and Spatial Orientation were all represented with at least two tests having reliabilities above .80.

The intercorrelations of the cognitive tests are given in Table 2. A cursory inspection of the intercorrelations reveals that tests representing different factors may have high intercorrelations; for instance, the Choosing a Path and Surface Development tests correlate .71 even though they represent the two factors, Spatial Scanning and Visualization. It is therefore to be expected that the factors will be highly correlated with one another.

This matrix was factor analyzed by the principal components method. The characteristic roots of the reduced correlation matrix are also listed in Table 2. To solve for communalities, the computer program iterated on the stability of the diagonal estimates using only roots greater than one. As a consequence, it underestimated somewhat the "true" communalities. For this reason, the communality estimates given in Table 1 are the sums of squares of loadings on the first five factors (instead of the final diagonal entries in the reduced correlation matrix), and it is these estimates that were used to compute the index of factorization.

Table 2

Intercorrelations of Cognitive Tests[a]

Tests (In Order of Presentation)	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Card Rotation	100												
2. Choosing a Path	46	100											
3. Concealed Words	25	21	100										
4. Copying	57	52	36	100									
5. Cube Comparisons	67	65	38	56	100								
6. Form Board	70	68	40	70	64	100							
7. Gestalt Completion	4	0	28	-7	20	5	100						
8. Hidden Figures	29	22	-4	38	24	34	20	100					
9. Hidden Patterns	54	63	33	63	54	68	21	25	100				
10. Map Planning	47	51	39	66	61	70	28	34	63	100			
11. Maze Tracing	47	61	28	49	48	52	31	21	64	54	100		
12. Paper Folding	49	52	45	45	56	63	13	19	55	65	48	100	
13. Surface Development	51	71	40	48	64	65	5	20	51	60	52	69	100

Characteristic Roots

1	6.1979
2	.4936
3	.3972
4	.2776
5	.1523
6	.0961
⋮	⋮
13	-.5270

[a]Decimal points have been omitted.

The first five factors were retained and rotated according to the equamax procedure. The equamax factor matrix is given in Table 3 with tentative identifications of the factors as column headings. (Each test name is followed by the number of the factor on which it was expected to load, assuming the tentative factor identifications were correct.) The Spatial Orientation factor emerged most clearly here with its two tests, Card Rotations and Cube Comparisons, having the only loadings above .50. Visualization was the next clearest factor to appear, with its three tests loading as follows: Form Board (.45), Paper Folding (.56), Surface Development (.48). Two other tests loaded highly on Visualization as well; they were Concealed Words (.46) and Map Planning (.48). The Map Planning Test loaded above .24 on all the factors, suggesting that it is a rather complex task.

The final oblique factor matrix, a result of the rotation to hypothesis and several graphic touch-up rotations (which allowed the Map Planning Test to load highly on several factors), is also given in Table 3, together with the final transformation matrix and the matrix of factor intercorrelations. The oblique factor matrix contains the projections of variables on the oblique reference axes. Since the angles between the reference axes are obtuse, these loadings are somewhat reduced, compared with the orthogonal factor loadings.

The last two factors, Spatial Orientation and Speed of Closure, are the clearest, with their representative tests loading above .30 and the irrelevant variables loading no higher than .15 and .22, respectively. The Visualization factor is also clearly present, although the Form Board Test did not load more more highly (.26) than the irrelevant Concealed Words Test. The first two

Table 3

Summary of the Factor Analysis

Rotated Orthogonal Factor Matrix

Cognitive Tests	Spatial Scanning	Flexibility of Closure	Visual-ization	Spatial Orientation	Speed of Closure
1. Choosing a Path (1)	.65	.23	.23	.41	.05
2. Maze Tracing (1)	.52	.26	.18	.23	.39
3. Copying (2)	.30	.61	.34	.28	.04
4. Hidden Figures (2)	.09	.40	-.01	.15	.15
5. Hidden Patterns (2)	.51	.44	.28	.21	.30
6. Form Board (3)	.39	.53	.45	.42	.05
7. Paper Folding (3)	.33	.16	.56	.34	.22
8. Surface Development (3)	.48	.11	.48	.46	.10
9. Card Rotation (4)	.24	.43	.22	.53	.07
10. Cube Comparisons (4)	.30	.27	.32	.61	.23
11. Concealed Words (5)	.09	.05	.46	.17	.28
12. Gestalt Completion (5)	.01	.02	.06	.00	.49
13. Map Planning (1)	.29	.44	.48	.24	.37

Oblique Transformation Matrix

	1	2	3	4	5
1.	.89	.09	.14	-.37	-.38
2.	-.12	.86	-.25	-.09	-.31
3.	-.24	-.19	.85	-.17	.29
4.	-.28	-.46	-.04	.91	.08
5.	.23	.03	-.43	.05	.82

Intercorrelations of Factors

	1	2	3	4	5
1.	1.00				
2.	.49	1.00			
3.	.54	.70	1.00		
4.	.69	.73	.68	1.00	
5.	.32	.47	.37	.27	1.00

Oblique Factor Structure

Cognitive Tests	Spatial Scanning	Flexibility of Closure	Visual-ization	Spatial Orientation	Speed of Closure
1. Choosing a Path (1)	.39*	.02	.20	.07	-.18
2. Maze Tracing (1)	.42**	.14	-.02	-.02	.11
3. Copying (2)	.04	.36*	.14	.04	-.14
4. Hidden Figures (2)	.02	.29	-.17	.07	-.03
5. Hidden Patterns (2)	.35*	.29	.06	-.07	.01
6. Form Board (3)	.07	.22	.26	.12	-.10
7. Paper Folding (3)	.10	-.09	.38*	.09	.20
8. Surface Development (3)	.20	-.16	.39*	.15	.04
9. Card Rotation (4)	-.02	.11	.06	.31*	-.06
10. Cube Comparisons (4)	.05	-.08	.12	.37*	.13
11. Concealed Words (5)	-.02	-.11	.26	.06	.33*
12. Gestalt Completion (5)	.11	.02	-.16	.01	.41**
13. Map Planning (1)	.11	.21	.17	.01	.22

*Absolute value of loading ≥ .30 and < .40; **absolute value of loading ≥ .40.

factors emerged less clearly, though all five of the oblique factors obtained were accepted as the cognitive variables desired.

The numbers in the principal diagonal of the oblique transformation matrix give the correlations between the final oblique factors and the equamax factors. The lowest of these correlations is .82, indicating that the oblique rotation did not involve especially large movements of the axes away from the equamax positions.

The oblique factors are highly intercorrelated--a finding that is not unusual with cognitive ability measures. In particular, Spatial Orientation correlates greater than .65 with all other factors except Speed of Closure, and Visualization correlates above .50 with Spatial Scanning, Flexibility of Closure, and Spatial Orientation.

The Factor Extension

No significant sex or eyesight (20-20 versus non-20-20 vision) differences were found for any of the extension variables, averaged over slides. The loadings of the extension or criterion variables on each of the oblique cognitive factors are given in Tables 4, 5, and 6, along with descriptive statistics for each slide. These loadings can be interpreted as correlations between variables and factors (Harmon, 1960, Chapter 2). Loadings of .30 or greater are high enough to merit consideration. Since the sample size is too small to justify any attempt to interpret individual factor loadings, we will be interested only in the number and direction of these high slide loadings for each of the criterion variables (slide recognition and number of early hypotheses). The extension loadings for the average (over slides) criterion variable scores are given in the last row of each table.

Slide recognition points. Since a high slide recognition score means poor performance (recognition occurring only after the slide is nearly in focus), a negative loading indicates that the cognitive ability is associated with good performance. The loadings in Table 4 for the subjects' slide recognition points indicate that not all slides are related in the same way to the cognitive factors. Spatial Scanning, for instance, facilitates slide recognition for a different subgroup of slides than does Spatial Orientation or Speed of Closure. It seems to contribute to early recognition only for slides occurring late in the sequence, after the subjects have had practice in recognizing.

Flexibility of Closure has no consistent relationship to slide recognition; five slides had high loadings (absolute value of loadings $\geq .30$) of which two were positive and three were negative.

Seven of the slides load highly and positively on Visualization, and only three loadings are negative. A high ability to visualize is associated with late slide recognition. Visualization is the only one of the cognitive abilities that did not facilitate slide recognition. Subjects who were good visualizers were also late slide recognizers.

Six of the seven high loadings on Spatial Orientation were negative, indicating that this ability may facilitate recognition on some slides. However, almost half of the 20 loadings were positive. The role of Spatial Orientation in slide recognition is equivocal.

Speed of Closure seems generally to contribute to early slide recognition; all but four loadings are negative, and all but one of the high loadings are negative. Subjects who had high scores on the Gestalt Completion and Concealed Words tests recognized the slides early.

Table 4

Loadings of the Extension Variables on the Oblique Cognitive Factors: Slide Recognition Points[a]

Criterion for Recognition	Mean	Standard Deviation	1 Spatial Scanning	2 Flexibility of Closure	3 Visual-ization	4 Spatial Orientation	5 Speed of Closure
1. Manhole cover, sewer cover	13.33	1.96	-.06	.01	.14	-.03	-.40**
2. Fence and hose	11.30	2.54	.12	.37*	.06	-.65**	-.12
3. Child with toys	13.50	2.68	-.20	-.16	.18	.20	-.21
4. Barge with crates	14.63	1.95	.07	-.38*	.46**	-.25	.25
5. Cupboard with dishes, cups	6.11	1.32	.12	.29	.29	-.40**	-.38*
6. Garbage cans, trash cans	12.48	3.05	.14	.00	.43**	-.41**	-.63**
7. Map	7.00	2.74	-.28	-.42**	.18	.31*	.54**
8. Bicycle(s)	6.93	2.05	-.13	.04	.07	-.14	-.12
9. Sky and/or house through leaves	11.83	1.77	-.03	-.27	.67**	-.18	-.35*
10. Fire hydrant	5.59	1.76	.14	.07	.35*	-.43**	-.49**
11. Fireplace tools	14.78	1.97	.26	.15	.03	-.39*	-.30*
12. Cow, bull, or buffalo, and person	11.33	3.00	-.09	-.20	.32*	.16	-.03
13. Shoes or boots	12.43	2.43	-.31*	.05	.53**	-.22	-.11
14. Cat	11.39	3.28	.01	.11	-.19	.24	-.17
15. Ashtrays	13.37	2.18	-.59**	.16	-.10	.27	-.17
16. Cloverleaf, superhighway	5.65	2.45	-.52**	.09	-.25	.26	.03
17. Jungle gym, monkey bars, climbers	13.26	2.44	-.25	-.37*	.22	.27	.15
18. Silverware, knives and forks	12.61	1.37	-.45**	.06	.32*	.08	-.16
19. Lifejackets, lifeboat drill	12.43	1.49	-.42**	.13	.18	.04	-.33*
20. Bricks, stones	11.89	2.95	.02	.31*	.06	-.34*	-.47**
Average Recognition Point	11.09	.74	-.36*	-.02	.55**	-.19	-.50**

[a]The recognition point is that stage of focus at which the criterion was first mentioned with no subsequent return to an incorrect hypothesis. These criteria were applied literally with no "interpretation" of the subject's comments. Therefore it was not deemed necessary to assess the reliability of scoring. A failure to recognize was scored as 16.

*Absolute value of loading $\geq .30$ and $< .40$; **absolute value of loading $\geq .40$.

The loadings of the average recognition point bear out the interpretation that Spatial Scanning (loading -.36) and Speed of Closure (loading -.50) are associated with early recognition, while Visualization (loading .55) is associated with late slide recognition.

Number of early hypotheses. The loadings of the subjects' numbers of early hypotheses on the five cognitive factors are given in Table 5. Only two of the factors have more than two high loadings; they are Visualization and Speed of Closure, the same two factors that appeared most clearly related to slide recognition. The other factors do not seem to be important determiners of hypothesis formation. Visualization and Speed of Closure have, respectively, 7 and 11 slides with high positive or negative loadings on them. The average number of hypotheses loads -.34 on the former and .46 on the latter. The ability to visualize is therefore negatively related to the forming of a large number of initial ideas, while Speed of Closure bears a positive relationship--subjects with high Speed of Closure scores tend to have many initial hypotheses. People with a high ability to visualize tend to produce few initial hypotheses.

Confidence ratings. In Table 6, the loadings of the confidence ratings on the cognitive factors are given for each slide. Only one factor, Speed of Closure, has more than five slides loading highly on it. Since all slides load positively on Speed of Closure, and since the average of the confidence ratings loads .55, it can be said that people who are successful at Gestalt Completion tasks also have high confidence in their initial hypotheses when recognizing slides. Interestingly enough, they are also good slide recognizers (there was a correlation of -.47 between the average recognition and confidence scores), which leads us to suspect that slide recognition and Speed of

Table 5

Loadings of Extension Variables on the Oblique Cognitive Factors: Number of Early Hypotheses for Each Slide[a]

Criterion for Recognition	Mean	Standard Deviation	1 Spatial Scanning	2 Flexibility of Closure	3 Visual-ization	4 Spatial Orientation	5 Speed of Closure
1. Manhole cover, sewer cover	1.93	1.12	.09	.46**	-.39*	-.04	.09
2. Fence and hose	2.11	1.32	.27	.07	.18	-.18	-.25
3. Child with toys	1.93	1.04	.05	.27	-.34*	-.01	.26
4. Barge with crates	1.87	1.28	-.02	.06	-.38*	.23	.47**
5. Cupboard with dishes, cups	1.70	1.30	.15	.18	-.28	.03	.06
6. Garbage cans, trash cans	2.15	1.38	-.05	-.07	-.20	.22	.55**
7. Map	1.37	1.25	-.24	-.05	-.22	.41**	.23
8. Bicycle(s)	1.89	1.34	-.06	.06	-.29	.13	.55**
9. Sky and/or house through leaves	1.48	1.17	.02	-.09	-.11	.17	.26
10. Fire hydrant	1.83	1.20	.23	.36*	-.10	-.25	.09
11. Fireplace tools	.76	1.18	-.03	-.06	-.07	.17	.34*
12. Cow, bull, or buffalo, and person	1.22	1.36	.12	.13	-.24	-.25	.38*
13. Shoes or boots	1.04	1.23	-.00	.21	-.13	-.06	.28
14. Cat	1.54	1.19	.04	.28	-.84**	.26	.43**
15. Ashtrays	1.74	1.37	.04	.13	-.35*	.24	.16
16. Cloverleaf, superhighway	1.43	1.09	-.21	.03	-.49**	.33*	.52**
17. Jungle gym, monkey bars, climbers	1.04	1.03	.04	-.00	-.29	.02	.60**
18. Silverware, knives and forks	1.24	1.34	-.25	-.22	.19	.06	.53**
19. Lifejackets, lifeboat drill	1.50	1.24	-.05	.06	-.34*	.27	.34*
20. Bricks, stones	1.09	1.03	.32*	-.08	-.21	-.18	.55**
Average Number of Early Hypotheses	1.54	.85	.03	.12	-.34*	.12	.46**

[a]The number of early hypotheses was defined as the total number of different hypotheses or ideas written during the first four stages of focus. Two ideas were considered "different" if (a) they were totally incompatible ideas, (b) something new was added to a previous idea so as to modify it, or (c) something previously written was declared wrong, while retaining some aspects of the previous ideas. In applying these scoring rules literally, questions arose in only 37 cases out of the total of 920 subject-slide pairs. Hence it was not deemed necessary to compute scoring reliabilities.

*Absolute value of loading $\geq .30$ and $< .40$; **absolute value of loading $\geq .40$.

Table 6

Loadings of the Extension Variables on the Oblique Cognitive Factors: Confidence Ratings[a]

Criterion for Recognition	Mean	Standard Deviation	1 Spatial Scanning	2 Flexibility of Closure	3 Visual- ization	4 Spatial Orientation	5 Speed of Closure
1. Manhole cover, sewer cover	5.13	3.81	-.02	-.47**	.23	.08	.09
2. Fence and hose	4.87	5.36	.03	-.00	.34*	-.52**	.14
3. Child with toys	6.00	5.38	-.14	.29	-.43**	.14	.33*
4. Barge with crates	4.67	4.00	-.12	-.05	-.13	.06	.42**
5. Cupboard with dishes, cups	3.37	3.41	.08	-.14	-.17	-.05	.46**
6. Garbage cans, trash cans	5.59	6.10	-.09	-.01	.04	.01	.40**
7. Map	2.59	3.24	-.02	-.02	-.32*	.02	.61**
8. Bicycle(s)	5.35	5.38	-.06	.20	-.11	-.06	.44**
9. Sky and/or house through leaves	3.33	4.26	.06	.01	.09	-.15	.26
10. Fire hydrant	8.70	8.73	.02	.21	-.36*	.06	.52**
11. Fireplace tools	2.04	3.88	.00	-.09	.19	-.24	.36*
12. Cow, bull, or buffalo, and person	4.57	5.70	.17	.16	-.04	-.51	.27
13. Shoes or boots	2.91	4.12	-.13	.10	.05	-.11	.37*
14. Cat	3.80	5.17	.11	.43**	-.25	-.35*	.16
15. Ashtrays	4.98	4.43	-.28	.00	.09	.08	.26
16. Cloverleaf, superhighway	5.26	5.40	.35*	-.10	-.46**	.16	.33*
17. Jungle gym, monkey bars, climbers	3.28	4.63	.19	-.07	-.18	-.13	.59**
18. Silverware, knives and forks	5.04	6.74	-.12	-.26	-.12	.28	.23
19. Lifejackets, lifeboat drill	4.48	4.59	.22	.20	-.12	-.38*	.36*
20. Bricks, stones	3.15	4.08	.05	-.11	.08	-.24	.61**
Average Confidence Rating	4.46	3.20	.02	.05	-.15	-.13	.55**

[a]The confidence ratings were defined as the sum of the ratings circled by the subject during the first four stages of focus.

*Absolute value of loading $\geq .30$ and $< .40$; **absolute value of loading $\geq .40$.

Closure may involve similar abilities. At any rate, people who were confident had some basis for being so, for they actually did recognize earlier.

The Analysis of Variance

It has already been noted that the pictures did not all require the same cognitive abilities for their recognition. Nevertheless, general effects of some of the cognitive abilities on slide recognition and hypothesis formation were noticed in the loadings of the average scores on the factors, and it was considered desirable to assess the significance of these over-all effects. To accomplish this, a multivariate analysis of variance (Jones, 1960) was carried out to see if a subject's average recognition score and his average number of early hypotheses could each be predicted by a single linear combination of his factor scores.

These average scores showed a fair degree of reliability. The odd-even reliability of the average slide recognition score was .58, indicating that a greater degree of subject consistency exists than was found by Bruner and Potter. The subjects showed even greater consistency in the total number of hypotheses they wrote down. The odd-even reliability of their average number of hypotheses was .94.

The subjects were trichotomized for the analysis of variance on the basis of the two criterion variables: slide recognition and hypothesis formation. In order to get equal numbers of subjects in all the cells of the resulting three-by-three classification table, subjects were moved from or into adjacent cells as necessary. In addition, one subject, randomly selected, was deleted from the middle cell.

The multivariate analysis of variance tests hypotheses concerning equal subclass mean vectors, the subclasses of subjects being the classifications described in the table above. Each subject is represented in the analysis by a vector containing his scores on the five cognitive factors. (The procedure used for obtaining factor scores is described in Appendix A.) Instead of obtaining a mean square for row, column, and interaction effects as in a conventional univariate analysis of variance, a mean-product matrix (the sum of outer products of group mean vectors) is computed for each effect. The roots of these matrices have properties which permit the use of an F-test of significance. The roots of these mean-product matrices for each effect are given in Table 7, along with the F-ratios and significance levels. The slide recognition effect approaches significance with p between .05 and .10, indicating that subjects could be sorted into their rows by looking only at their cognitive factor scores. Considering the crudity of the test (it employed trichotomized data) and the small size of the sample, this finding was considered encouraging.

Associated with the row effect is a discriminant function, also given in Table 7. The discriminant function is that linear combination of the subjects' factor scores which best predicts in which rows the subjects fall. The obtained discriminant function supports the previous analysis based on the factor extension loadings. Again we see that two of the factors contribute to early slide recognition and one (Visualization) interferes with recognition. We can only conclude from Table 7 that the cognitive abilities are not good predictors of the number of early hypotheses. However, some relationship may still exist--that which was revealed in the more sensitive factor extension procedure.

Since continuous data were available for the subjects' recognition performance, we can make a scatterplot of the subjects' average recognition

Table 7

Two-Way Multivariate Analyses of Variance[a]
Tests of Significance

	Effect		
	Total Slide Recognition	Number of Hypotheses	Interaction
D.F.H.	2	2	4
D.F.E.	36	36	36
Root 1	6.72	2.61	3.72
Root 2	3.02	.93	1.18
Root 3	--	--	.46
Root 4	--	--	.04
Likelihood Ratio	.62	.83	.59
F-Ratio	1.72	.62	.92
D.F. Used in F-Test	10/64	10/64	20/125
Probability	$.05 < p < .10$	n.s.	n.s.

Discriminant Function

Total Slide Recognition

$$V = -.30x_1 - .04x_2 + .30x_3 + .05x_4 - .51x_5$$

[a]The subjects were trichotomized on the basis of two variables (mean recognition point and mean number of early hypotheses), resulting in the following 3 x 3 table:

	Highest 1/3 on B.	Middle 1/3 on B.	Lowest 1/3 on B.
Highest 1/3 on A.	5	5	5
Middle 1/3 on A.	5	5	5
Lowest 1/3 on A.	5	5	5

In order to get equal numbers of subjects in all the cells, subjects were moved from or into adjacent cells as necessary. Five subjects were reclassified in this way. In addition, one subject was deleted at random from the middle cell.

scores against their discriminant function scores. This plot is given in Figure 1, illustrating one prediction of the subjects' average recognition scores that can be made from a single linear combination of their factor scores. The correlation associated with the scatterplot is .495, which is significantly different from zero at the .001 level. The three abilities Spatial Scanning, Visualization, and Speed of Closure, and to a lesser extent the other two, account for nearly all of the reliable variance--the odd-even reliability of the total slide recognition score was .58.

To illustrate the multidimensional character of the set of slides, the scatterplot in Figure 1 can be compared with another one in which, instead of using a <u>single</u> equation to predict recognition, we use a <u>separate prediction equation for each slide</u>. This has been done in Figure 2, which illustrates the best prediction of average slide recognition where differences in the abilities involved for each slide are taken into account. The predicted average recognition points were the averages of 20 separate predicted recognition points, one prediction for each slide, and each prediction a separate linear combination of the subjects' cognitive factor scores. The coefficients in the prediction equations were the extension loadings of each slide on the five (equamax) cognitive factors. The correlation between the multivariate predicted recognition points and the obtained average recognition points was .893, indicating that all but about 20% of the variance has been accounted for. It should be pointed out, however, that with 20 prediction equations, the increased number of degrees of freedom capitalize on chance covariations in this sample. A more convincing demonstration of the predictability of slide recognition would involve the application of these equations to data for a new group of subjects.

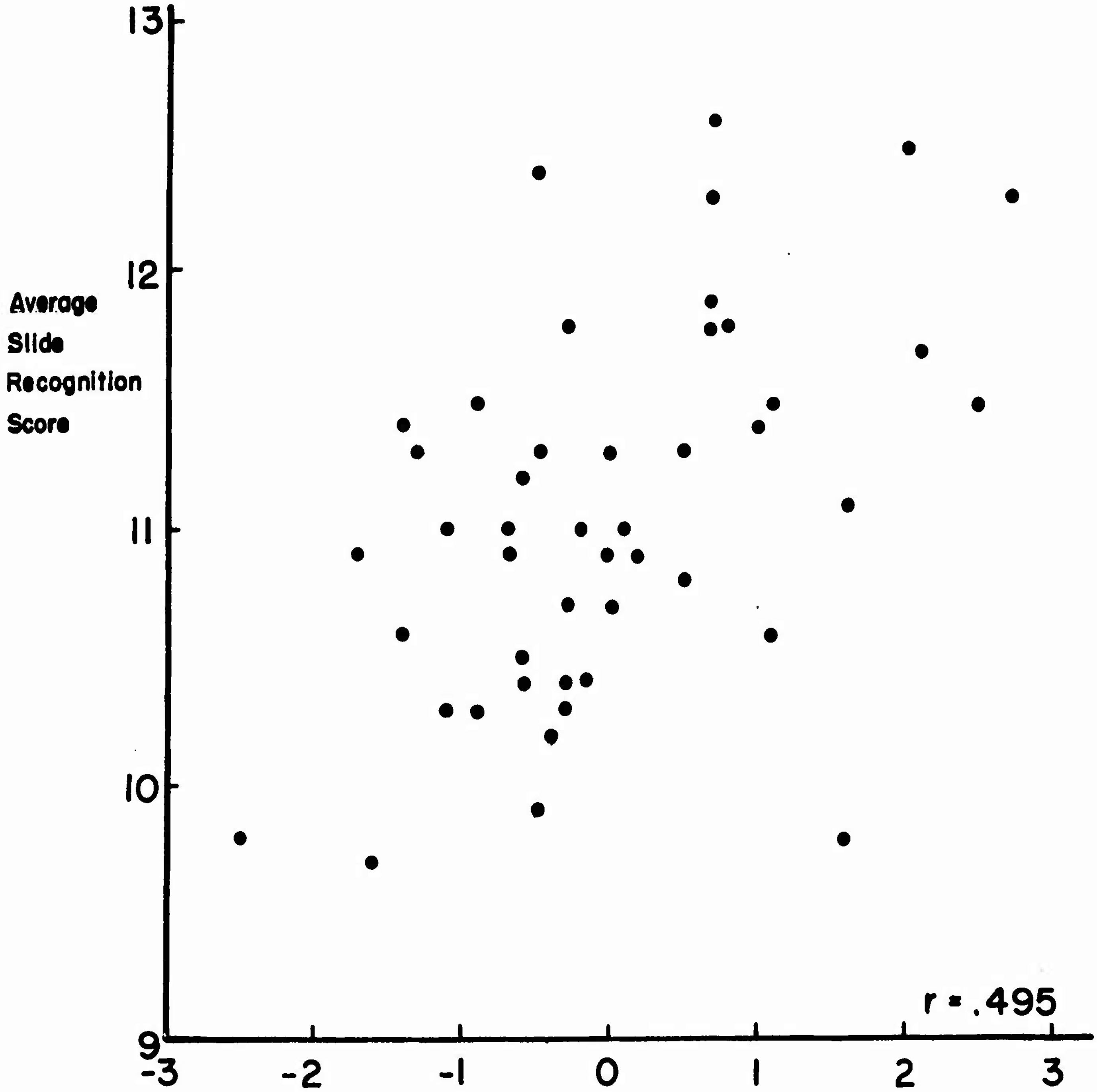

Fig. 1. A scatter plot of the subjects' average slide recognition scores against their discriminant function scores, illustrating one prediction of the subjects' recognition scores using a single linear combination of their factor scores.

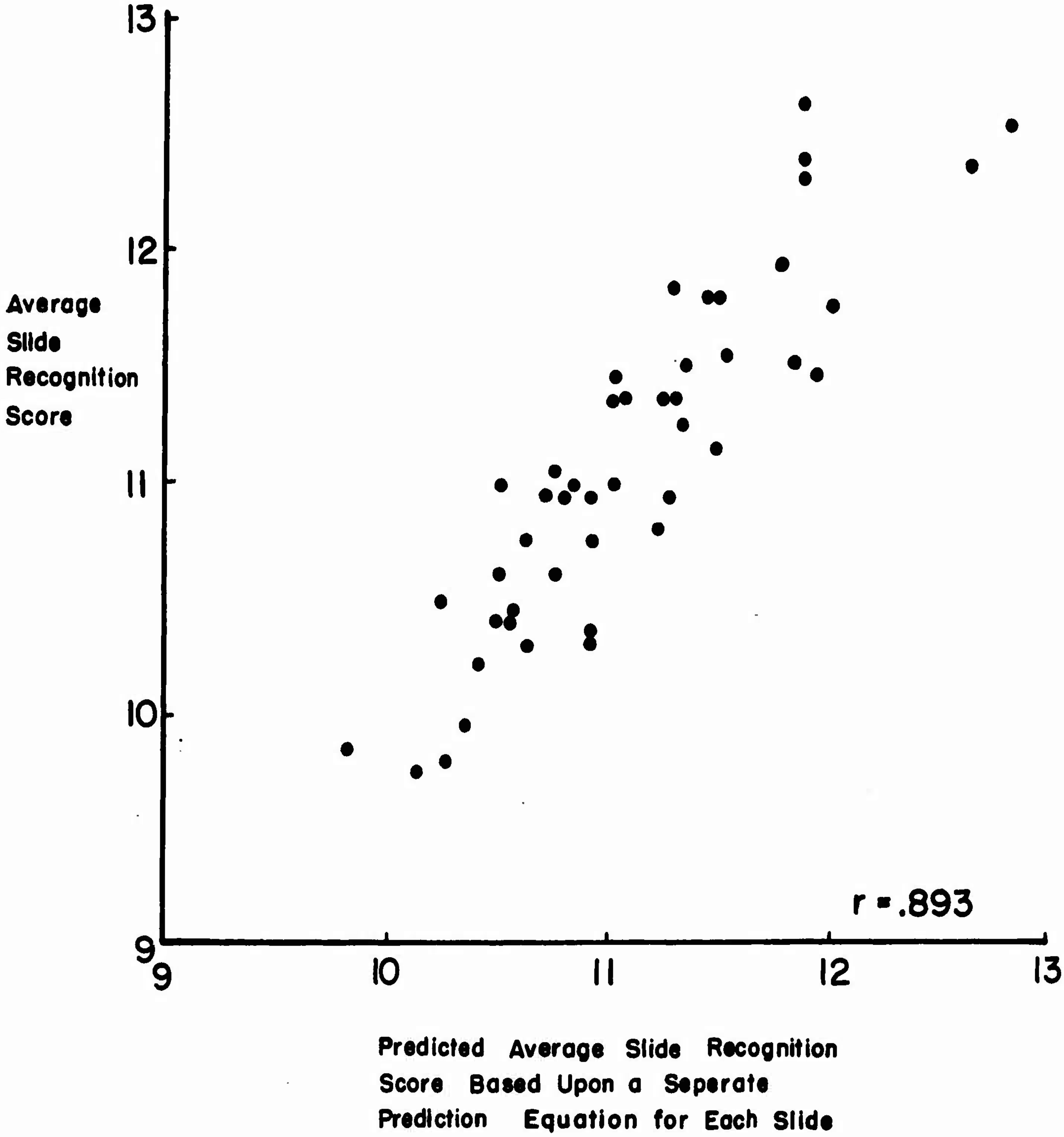

Fig. 2. A scatter plot of the subjects' average slide recognition scores against their predicted average recognition scores. The predictions are the averages of twenty linear combinations of the subjects' cognitive factor scores, one prediction equation for each slide. The coefficients in the prediction equations were the extension loadings of each slide on the five (equamax) cognitive factors.

By using multiple criteria in predicting average slide recognition, we have accounted for roughly 55% more of the variance than was accounted for using a single prediction equation. This explains why the odd-even reliability of the total recognition score was only .58. We conclude that the differences between slides are important determiners of perceptual recognition and are variables that should not be disregarded. Nevertheless, this paper is concerned primarily with the cognitive abilities as sources of variation in recognition behavior, that is, with the single prediction equation illustrated in Figure 1.

The Relation between Slide Recognition and Hypothesis Formation

It has already been seen that (1) while Visualization interferes with early slide recognition, it is associated with formulating few early hypotheses; and (2) while Speed of Closure contributes to early slide recognition, it is associated with many early hypotheses. These findings lead us to suspect that there is a relationship between having a lot of ideas (fluency) and recognizing early, i.e., we expect to find a negative correlation between average slide recognition score and average number of early hypotheses. The correlation obtained was -.34 which, considering the unreliability of the two variables correlated, is fairly high. Corrected for attenuation (using odd-even reliabilities of .58 and .94 for total slide recognition and number of hypotheses, respectively), the correlation between these two variables was -.46. Evidently, having many initial ideas tends to facilitate early recognition rather than interfere with it.

Also, as one would expect, subjects who formulated many initial hypotheses tended to be more confident in the validity of their hypotheses.

The correlation obtained between the average number of hypotheses and the confidence ratings, corrected for attenuation, was .49.

Discussion

These findings about the relationships among the ability variables, total recognition scores, hypothesis formation rates, and confidence ratings have implications for a theory of perceptual recognition. It has been suggested by Bruner (1951) that perception involves a three-step cycle which begins with an expectancy or hypothesis resulting from the arousal of central cognitive processes by antecedent environmental factors. Next, information from the environment is obtained, and, finally, congruence between hypothesis and environment is tested in a checking operation (Bruner, 1951, pp. 123-124). In the hypothesis testing or checking operation, according to Bruner, the particular hypothesis operative at the time is found either to conform to the stimulus array or to be nonconforming. If confirmation does not occur, a shift in hypothesis is produced; the direction of the shift is determined partly by internal cognitive factors and partly by the information from the previous information-checking cycle. It may be reasonable to reverse the first two steps in Bruner's model, in order to stress the role of the stimulus in the formation of hypotheses, producing a model having an Input-Hypothesize-Test sequence.

Within this framework, one way to explain the interference of unverified hypothesizing on subsequent recognition is to say, as do Bruner and Potter (1964), that the amount of exposure necessary to generate a new hypothesis is exceeded by that necessary to invalidate the previous hypothesis. Then, at any particular degree of ambiguity, subjects who see the stimulus for the first time are more likely to recognize the picture than subjects who have had some prior exposure to the ambiguous stimulus. This explanation implies that subjects test hypotheses sequentially. At a given stage of focus, subjects who come into the situation with strong unconfirmed hypotheses will spend their time testing these hypotheses and fail to develop new and possibly correct ones.

We have seen, however, that subjects who generate many early hypotheses are more efficient recognizers. The more hypotheses one generates, the earlier one recognizes the picture. In other words, the more often the subject runs through the Hypothesize-Test sequence, the greater his likelihood of recognizing. During the scoring of the protocols, it was noticed that a subject would often retain a hypothesis over many stages of focus without definitely rejecting it, meanwhile testing other hypotheses. Hypothesis testing, therefore, does not result in a distinction between acceptance or rejection of the hypothesis; instead a hypothesis is either confirmed or held at some lower level of likelihood. Thus, it is possible to generate new hypotheses without rejecting all previous ones. The explanation of recognition need not assume a sequential testing of hypotheses. These results, therefore, cast doubt upon a theory of interference in visual recognition which states that early erroneous hypotheses inhibit recognition. On the contrary, we have seen that having many early erroneous hypotheses helps recognition.

How then are we to explain the phenomena of visual recognition? A clue to the processes involved is found in the role played by Visualization, a mental operation defined as "the ability to manipulate or transform the image of spatial patterns into other visual arrangements" (French et al., 1963). It is possible that, given ambiguous input, visualizers manipulate and transform their images of the visual input so as to make them conform to their hypotheses, and thereby increase the probability of erroneously accepting them. What is desired now is a means of integrating this notion of a mental operation mediating visual recognition with the notion of an Input-Hypothesize-Test sequence.

Miller, Galanter, and Pribram (1960) have developed the idea of the TOTE-unit as a general mediational model for behavior involving environmental feedback. The Test-Operate-Test-Exit concept can be applied to the recognition model. After each test of a hypothesis, one or more operations can be performed before the next test of a hypothesis. Two kinds of operations are possible: (1) operations on the image of the input (e.g., Visualization), and (2) operations involving hypothesis change (generation of hypotheses or fluency).

Bunderson (1964) has suggested the conceptualization of cognitive abilities as mental "subroutines" and the use of computer programming language as a vehicle for formulating theories involving mental abilities. These ideas were incorporated in the construction of Figure 3, which is a model illustrating one way of conceptualizing the role played by cognitive abilities in a complex perceptual task. The notation is similar to that used in computer flow diagrams. Ovals stand for branch points and rectangles stand for mental operations. Each ability has associated with it a branch statement and an operation. The operation is a subroutine representing the mental ability. The branch point associated with an ability may be thought of as its personality component--that aspect of an ability which involves a consistency in or preference for a particular strategy.

In Figure 3, the Input-Hypothesize-Test sequence is simply Bruner's perceptual model restated in the new notation. Included as input are the

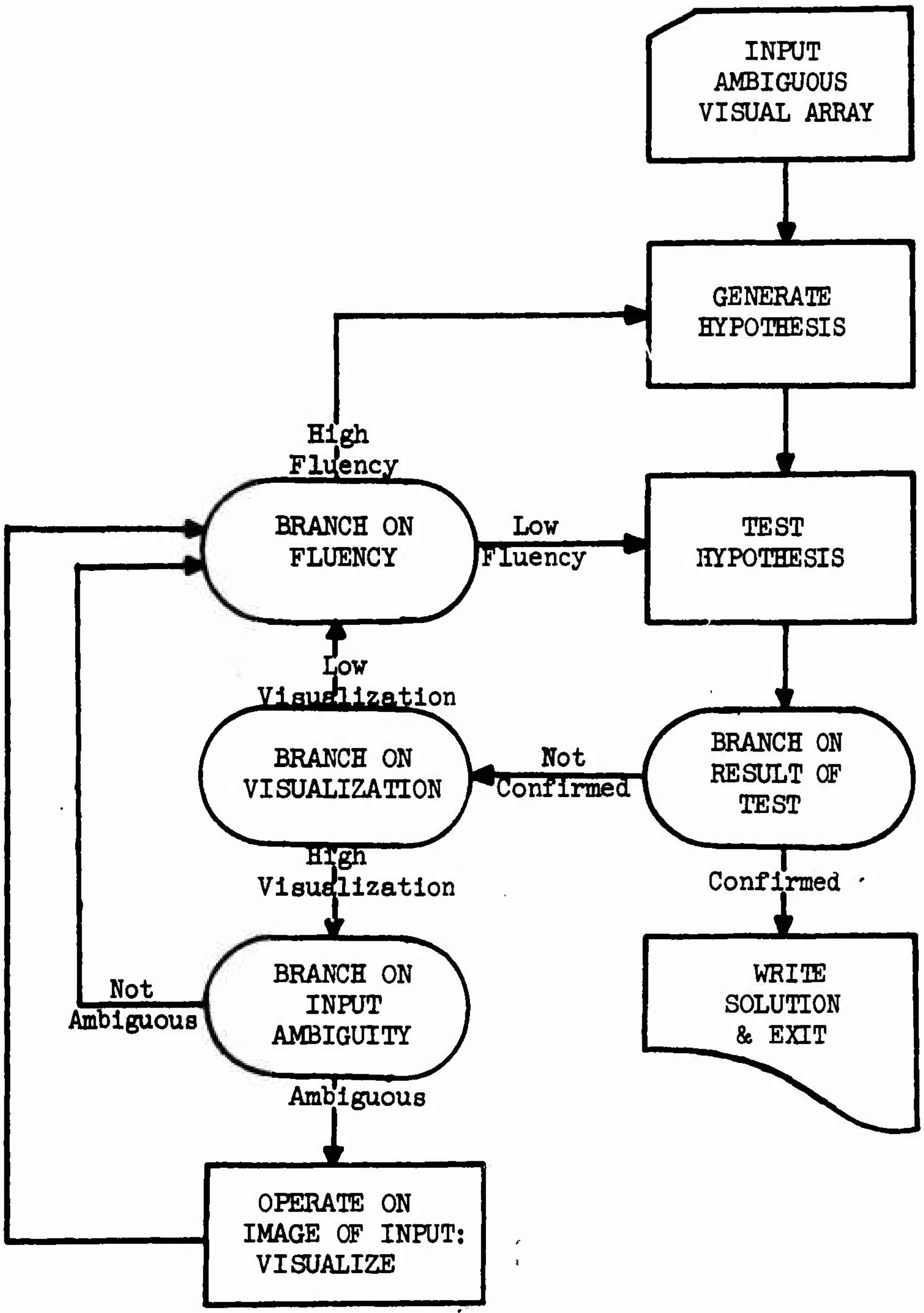

Figure 3. A theoretical model illustrating one way of conceptualizing the role played by cognitive abilities in a complex perceptual task. The notation is similar to that used in computer flow diagrams. Ovals stand for "if" statements and rectangles stand for operations. Each ability has associated with it an "if" statement and an operation. See the text for discussion.

expectancies and hypotheses resulting from previous experience, as well as the information imparted by the stimulus. The hypothesis testing operation results in either confirmation of the hypothesis (followed by an exit) or nonconfirmation, which is followed by the operate phase of the TOTE-unit. Several operations are possible. One of these is the generation of new hypotheses. The ability to produce new hypotheses, which we might call fluency, has associated with it a branch point which controls the extent to which new hypotheses are produced. People who are fluent will be more likely to generate new hypotheses after testing their old ones than people who are not fluent. Measures of the fluency variable were not included in the present study, but such an ability may be highly relevant. Furthermore, provided that fluency is an independently measurable ability which determines how many hypotheses are produced, we can account for the result that having many hypotheses is correlated with early slide recognition. Subjects who are fluent will tend to re-enter the Input-Hypothesize-Test sequence at the Hypothesize point, whereas people who are not fluent will have a tendency to simply retest their old hypotheses. In other words a high correlation is predicted between measures of fluency (or possibly other divergent production abilities) and early slide recognition.

Several alternative routes to the fluency branch point are available when a hypothesis has not been confirmed. If a subject is a good visualizer, and if the input is highly ambiguous, the subject will transform his image of the input so as to make it conform to his hypothesis, thereby raising the probability that his hypothesis will be accepted the next time he tests it. Visualization thus interferes with slide recognition by increasing the probability that incorrect hypotheses will be accepted. If an incorrect hypothesis is accepted, an exit occurs, no more hypotheses are generated, and recognition is delayed. The model in this way incorporates the findings of the factor extension and multivariate analysis of variance procedures.

The inclusion of a branch point associated with ambiguity of input is a means of incorporating into the model the hypothesis (yet to be confirmed) that omission of initial out-of-focus stages should facilitate recognition for subjects who are good visualizers--primarily on slides that load highly on Visualization. Low visualizers should not be susceptible to the interference effects of ambiguous stimuli. The effect of the ability to visualize is therefore hypothesized to be conditional on stimulus ambiguity.

For purposes of diagrammatic representation, each ability has been represented by an "either-or" branch and a subroutine. If we were to write a computer simulation using this model, it would be more parsimonious to associate with each branch point a probability of taking either of the branches than to write a separate set of subroutines for each ability level. These probabilities would be functions of the subjects' factor scores on the cognitive abilities concerned (Visualization and Fluency). Similarly, the path taken at the branch point associated with stimulus ambiguity would be determined by the degree of focus. In this way, the probability of confirming a hypothesis depends on input ambiguity <u>and</u> ability to visualize.

To summarize the predictions which must be confirmed if this model is to hold, consider an analysis of variance table in which subjects have been separated into groups which are high and low on two ability measures. For the row labels we have High and Low Visualization Ability and for the column headings we have High and Low Fluency. The subjects' scores--the entries inside the table--are their average recognition points. We can construct a second analysis of variance table by repeating this experiment while omitting the most blurred stages of focus. The model predicts both significant row and column effects in the first analysis of variance table, and only significant column effects in the second table. In either table, no significant interaction effects are predicted.

The prediction for the first analysis of variance table has been partially confirmed, in that slide recognition loaded .55 on Visualization and correlated -.46 with hypothesis formation (number of hypotheses). The fact that hypothesis formation loaded .49 on Visualization suggests that people who visualize spend their time transforming their perceptions of the input, and therefore spend less time suggesting new hypotheses. Such an interaction effect would not be expected with an independent measure of fluency.

The major findings of this study are summarized in Table 8, which contains the correlations (or, in some cases, the extension loadings, which can be interpreted as correlations) among the key variables. Compare the patterns of numbers in the first and fifth columns. Suppose that slide recognition and Speed of Closure (the Gestalt Completion tasks) require the same complex combination of abilities for successful performance. This is a reasonable assumption, since both problems require the subject to identify ambiguous stimuli; in the case of slide recognition the ambiguity is created by changing the focus, and in the Gestalt Completion tasks it is created by deleting part of the figure. Then, since a high recognition point means poor performance while a high Speed of Closure score indicates good performance (many items recognized), we might expect to find for every high number in column one, a high number with the opposite sign in column five. This is

Table 8

Summary of the Correlations
Among the Key Variables[a]

	Recog. Point	Number Hypoth.	Confid. Rating	Visual-ization	Speed of Closure	Spatial Scanning
Recognition Point	.58	-.46[b]	-.47[b]	.55[c]	-.50[c]	-.36[c]
Number of Hypotheses	-.46[b]	.94	.49[b]	-.34[c]	.46[c]	.03[c]
Confidence Rating	-.47[b]	.49[b]	.93	-.15[c]	.55[c]	.02[c]
Visualization	.55[c]	-.34[c]	-.15[c]	--	.37	.54
Speed of Closure	-.50[c]	.46[c]	.55[c]	.37	--	.32
Spatial Scanning	-.36[c]	.03[c]	.02[c]	.54	.32	--

[a]Diagonal entries are reliabilities.

[b]Correlations corrected for attenuation.

[c]Loadings of extension variables on cognitive factors.

indeed the case for every variable except Visualization, on which slide recognition loads .55 and with which Speed of Closure correlates .37.

The items in the tests for Speed of Closure, however, do not involve manipulation of the degree of ambiguity and, hence, the test scores do not reflect the interference effects of early hypothesizing on later recognition. For this reason, under the hypotheses of the present model, a negative correlation between Speed of Closure and Visualization is not to be expected. The tentative conclusion is, therefore, that Speed of Closure should not be considered a separate, unitary, cognitive ability. It is further suggested that Gestalt Completion scores will, when each item is systematically presented at varying degrees of ambiguity (masking), exhibit the same interference effects that have been observed in experiments in perceptual recognition (e.g. Bruner & Potter, 1964).

Speed of Closure was not included in the present model for perceptual recognition, since it was felt that the correlation between Speed of Closure and slide recognition could be explained, as we have seen, in terms of the similarities between the two tasks. If Speed of Closure were to be considered a distinct ability, "the ability to unify an apparently disparate perceptual field into a single percept" (French et al., 1963), then it could be thought to facilitate recognition by contributing to the efficiency of hypothesis testing and/or to a structuring of the visual field prior to hypothesis formation. Since the ability is involved in tasks in which a perceptual field containing disparate parts is viewed, it probably would play no part during the most blurred stages of focus and therefore would not be related to the interference phenomenon.

The role played by Spatial Scanning, which is defined as "speed in visually exploring a wide or complicated spatial field" (French et al., 1963), is little understood. This ability may facilitate recognition late in practice by contributing to more efficient hypothesis testing through the inclusion of more details from all parts of the stimulus field in making the test.

The relationship between Visualization and Perceptual Recognition alters what we mean by the ability to visualize, as well as facilitating the analysis of the recognition process. It is thought that people who visualize can manipulate their images of the visual input to make them conform to their hypotheses. Added to the former conception of Visualization is the notion of filtering or transforming input information in order to make it bear out some pre-established schema about the stimulus situation. People who visualize may also have high scores on measures of rigidity and perform poorly in functional fixedness tasks.

References

Bechtoldt, H. P. Factor analysis and the investigation of hypotheses. Percept. mot. Skills, 1962, 14, 319-342.

Blake, R. R., & Vanderplas, J. M. The effect of pre-recognition hypotheses on veridical recognition thresholds in auditory perception. J. Pers., 1950, 19, 95-115.

Bruner, J. S. Personality dynamics and the process of perceiving. In R. R. Blake and G. V. Ramsey (Eds.), Perception: An approach to personality. New York: Ronald, 1951.

Bruner, J. S. & Potter, M. C. Interference in visual recognition. Science, 1964, 144, 424-425.

Bunderson, C. V. Transfer functions and learning curves: the use of ability constructs in the study of human learning. Research Bulletin 64-62. Princeton, N. J.: Educational Testing Service, 1964.

Cliff, N. Analytic rotation to a functional relationship. Psychometrika, 1962, 27, 283-295.

Davison, G. C. The negative effects of early exposure to suboptimal visual stimuli. J. Pers., 1964, 32, 278-295.

Frederiksen, J. R. Scaling of focus. Harvard Center for Cognitive Studies, 1963. (Dittoed Memorandum)

French, J. W. The description of aptitude and achievement factors in terms of rotated factors. Psychometric Monograph No. 5, 1951.

French, J. W., Ekstrom, R. B., & Price, L. A. Manual for kit of reference tests for cognitive factors. Princeton, N. J.: Educational Testing Service, 1963.

Galloway, C. I. An experimental investigation of structural lag in perception. Amer. Psychologist, 1946, 1, 450. (Abstract)

Harmon, H. H. Modern factor analysis. Chicago: University of Chicago Press, 1960.

Horst, P. Matrix algebra for social scientists. New York: Holt, Rinehart and Winston, 1963.

Hurley, J., & Cattell, R. The Procrustes program: Producing direct rotation to test an hypothesized factor structure. Behav. Sci., 1962, 7, 258-262.

Jones, L. V. Some illustrations of psychological experiments designed for multivariate statistical analysis. Report of the Psychometric Laboratory, University of North Carolina, Chapel Hill, N. C., 1960, Number 28.

Miller, G. A., Galanter, E., & Pribram, K. H. Plans and the structure of behavior. New York: Holt, Rinehart and Winston, 1960.

Potter, M. C. Visual recognition at different ages. Paper presented at Eastern Psychological Association meetings, April 28, 1962.

Wyatt, D. F., & Campbell, D. T. On the liability of stereotype or hypothesis. J. abnorm. soc. Psychol., 1951, 46, 496-500.

APPENDIX A

Appendix A

A. A mathematical outline of the methods of analysis employed in the study.

1. The factor model. Let Z be an $N \times n$ matrix of approximations to the standardized scores for N subjects on n variables. Let M be an $N \times r$ matrix of subjects' factor scores on r factors, and let F be an $n \times r$ matrix containing the factor loadings of n variables. Then the basic factor model can be written (Harmon, 1960)

$$Z = MF' \tag{1}$$

where F is defined such that $R = FF'$, where R is the reduced correlation matrix $(n \times n)$ containing communalities in the diagonals. This is equivalent to saying that $(M'M)/N = I$, since

$$R = \frac{Z'Z}{N} = \frac{FM'MF'}{N} = FF' \ . \tag{2}$$

2. Oblique factors. Let H be an $n \times r$ matrix containing the rotated factor loadings of the variables, and let T be a transformation matrix and define $H = FT'$, and $G = MT^{-1}$.

Then

$$Z = MT^{-1}TF' = GH' \ . \tag{3}$$

When the columns of G have zero mean and unit variance, we can find the matrix of intercorrelations among the factors

$$Q = \frac{G'G}{N} = \frac{(T^{-1})'M'MT^{-1}}{N} = (T')^{-1}T^{-1} \ . \tag{4}$$

Since $(M'M)/N = I$, this condition for G will be met whenever the columns of T^{-1} have unit length, that is, when they contain the direction cosines of the new coordinate system after the transformation. We are interested in picking T' with columns of unit length, such that $FT' = H$, since our transformations will be determined by the pattern of variables' loadings (rather than by the subjects' factor scores). Since in general having the columns of T' of unit length does not imply that the columns of T^{-1} are also of unit length, Q can not be said to contain the intercorrelations of the factors without first rescaling the columns of T^{-1}. We can then compute the matrix of factor intercorrelations

$$Q_a = (T_a^{-1})'(T_a^{-1}) \tag{5}$$

where T_a^{-1} has columns of unit length.

3. <u>Method for computing T.</u> Assume that the variables in the factor analysis have been previously studied and that their factor structure can be hypothesized. It is then possible to construct a matrix H containing the hypothesized loadings of the variables on each of the factors. The hypothesis matrix employed in this study contained simply ones and zeros, each variable having a loading of unity on one factor and loadings of zero on all the other factors. Setting up a hypothesis matrix such as this implies that one is just as much interested in having many near-zero loadings as in having certain high loadings. Given H we want to find T' such that

$$\hat{H} = FT' \tag{6}$$

where $\hat{H}$ approximates H. One procedure for finding T', described by Hurley and Cattell (1962), minimizes the squares of the discrepancies between the loadings in H and those in $\hat{H}$. The following expression for T' is obtained from equation (6):

$$T' = (F'F)^{-1}F'H. \tag{7}$$

However, we must place the additional restriction on T' that it have columns of unit length, and use the resulting rescaled transformation matrix T_1' in the actual rotations. The rescaling of T' can be accomplished by forming a diagonal matrix D_2 whose elements are the diagonal elements of the matrix product TT'. The rescaled transformation matrix can then be found by the relation

$$T_1' = T'(D_2)^{-\frac{1}{2}} \quad . \tag{8}$$

Cliff (1962) has suggested that this rescaling of the transformation matrix is equivalent to minimizing the quantity

$$\sum_j \frac{(h_{jm} - \hat{h}_{jm})^2}{\sum_j \hat{h}_{jm}^2} \tag{9}$$

where h_{jm} is the element in the j^{th} row and the m^{th} column of H, and $\hat{h}_{jm}$ is similarly an element of $\hat{H}$.

In this study, after rotating to hypothesis using equations (7) and (8), further "touch-up" graphic rotations were made to improve the simple structure properties of $\hat{H}$ while, at the same time, allowing one variable (test 9) to load highly on several factors.

4. The factor extension procedure. Let R_t denote the following supermatrix, containing the intercorrelations of the n variables used in the factor analysis and p additional extension variables:

$$R_t = \left[\begin{array}{c|c} R & L \\ \hline L' & S \end{array}\right] \tag{10}$$

where R was defined in (2), S contains the intercorrelations of the p extension variables, and L is an $n \times p$ matrix of correlations between factor tests and extension variables. R_t is then a square matrix of order $n + p$. We can write

$$\left[\begin{array}{c|c} R & L \\ \hline L' & S \end{array}\right] \doteq \left[\begin{array}{c} F \\ \hline E \end{array}\right] \left[\begin{array}{c|c} F' & E' \end{array}\right] \qquad (11)$$

where F was defined in (2), and E contains the loadings of the p extension variables on the r factors. In (11), $R = FF'$, $\hat{S} = \hat{E}\hat{E}'$ and $L = F\hat{E}'$ where $\hat{S}$ approximates S and $\hat{E}'$ approximates E' . Using the least squares procedure described in Horst (1963, p. 491) to find the approximation to E' given F and L , we find that

$$\hat{E}' = (F'F)^{-1}F'L \ . \qquad (12)$$

The matrix of residual extension variable intercorrelations is given by

$$W = S - \hat{E}\hat{E}' \ . \qquad (13)$$

The matrix W can be factored to determine if any communality among the extension variables remains to be accounted for. (It is assumed that any remaining extension variable factors will not correlate with uniqueness in the factor test variables.) The extended factor matrix $[F|E]'$ can be post-multiplied by the transformation matrix T_1' , previously obtained in the rotation of the factors of R , to produce the oblique extended factor matrix which is reported.

5. Outline of computations. In the following equations, all symbols are as previously defined.

(1)	$R = U\beta U'$	Where β contains the characteristic roots of R and U the corresponding characteristic vectors in its columns.
(2)	$F = U\beta^{\frac{1}{2}}$	Definition of the factor matrix in the initial solution.

(3)		Rotate the first five columns of F analytically according to the equamax procedure to obtain F_e .
(4)	$T' = (F_e'F_e)^{-1}F_e'H$	Oblique rotation to hypothesis H .
(5)	$T_1' = T'(D_2)^{-\frac{1}{2}}$	Adjustment of the lengths of the columns of T' to unity.
(6)	$\hat{H} = F_eT_1'$	Computation of the oblique factor matrix $\hat{H}$.
(7)	$H_2 = \hat{H}T_2'$	T_2 is found by graphical rotation of $\hat{H}$, and the final oblique factor matrix H_2 is computed.
(8)	$Q_a = D_1(T_2T_2')^{-1}D_1$	Q_a is the matrix of intercorrelations of the factors; D_2 is picked so that the principle diagonal of Q_a contains unities.
(9)	$\hat{E}' = (F_e'F_e)^{-1}F_e'L$	Extension of the equamax factors to the slide extension variables.
(10)	$\begin{bmatrix} F_e \\ \hat{E} \end{bmatrix} T_2' = \begin{bmatrix} H_2 \\ E_2 \end{bmatrix}$	Rotation of extended factor matrix by the previous transformation.
(11)	$W = S - \hat{E}\hat{E}'$	Computation of the residual extension variable intercorrelations.
(12)	$G = \underline{Z}H_2(H_2'H_2)^{-1}$	The factor scores are obtained from the matrix of standardized test scores $\underline{Z}$ and the final oblique factor matrix H_2 .

APPENDIX B

Appendix B

Sample Response Booklet

Name ______________________________

Age __________

Field of Concentration ____________________

Year of Graduation __________

Do you have 20-20 vision (either corrected or uncorrected)? ( ) Yes

( ) No

This a test to determine how well you can recognize pictures presented out of focus. You will be shown 20 pictures, each of which will come slowly into focus in 15 steps of focus. Each stage of focus will be presented for 10 seconds, during which time you are to study the picture and try to guess what it is. The slides are all ordinary color slides of objects which would be immediately recognizable to you if they were seen in full focus. Try to determine what each picture is of as soon as you can; the earlier you recognize the picture, the higher will be your score.

Try to form your hypotheses about the subject of the slide during the 10 seconds while the slide is on the screen. Use these 10 seconds to study the slide. Do not write anything down while the slide is on the screen.

After each stage of focus is presented you will have another 15 seconds in which to write down your idea or ideas. Keep your written statements as short as possible. If you have several ideas, write them in the order of their likelihood. If your ideas about the picture at a stage of focus are the same as at the previous stage, write the word "same" in the box.

During the 15 seconds following each stage of focus you are also to indicate your degree of certainty about the slide by circling <u>one</u> of the numbers on the scale which is included in each box in the response booklet. The scale looks like this: (No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
If you have absolutely no idea what the slide is a picture of, you should circle the number 0 on the scale. If you are absolutely certain about the subject of the slide, you should circle number 10. If you think you have about a 50-50 chance of being correct, you should circle 5 on the scale. Circle the number clearly (as in the example above).

Make sure that you use the proper box for responding at each stage of focus; since you are to respond to every stage of focus, you can simply work the boxes consecutively.

Finally, there will be a short pause between slides, during which you should fill in the number of the next slide, which will appear on the screen.

RESPONSE SHEET FOR SLIDE NUMBER _____

FOCUS STAGE 1:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 2:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 3:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 4:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 5:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 6:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 7:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 8:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 9:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 10:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 11:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 12:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 13:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 14:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)
FOCUS STAGE 15:	
Circle one number:	(No idea) 0 1 2 3 4 5 6 7 8 9 10 (Absolutely certain)

GO ON TO NEXT PAGE

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Educational Testing Service Rosedale Road Princeton, New Jersey 08540	2a. REPORT SECURITY CLASSIFICATION 2b. GROUP

3. REPORT TITLE

THE ROLE OF COGNITIVE FACTORS IN THE RECOGNITION OF AMBIGUOUS VISUAL STIMULI

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Technical Report

5. AUTHOR(S) (Last name, first name, initial)

Frederiksen, John R.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
July 1965	51	18

8a. CONTRACT OR GRANT NO. Nonr 1858-(15) b. PROJECT NO. NR-150-088 c. NSF Grant G-22889 d.	9a. ORIGINATOR'S REPORT NUMBER(S) RB-65-23 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. AVAILABILITY/LIMITATION NOTICES

Qualified requester may obtain copies of this report from DDC.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Office of Naval Research 207 West 24th Street New York, New York 10011

13. ABSTRACT The effect of five cognitive abilities on the recognition of out-of-focus pictures was investigated using a factor extension procedure which is sensitive to differences among the slides in the abilities they require for recognition. In addition to recognition point measures, the subjects received scores reflecting their rate of hypothesis formation during the early stages of blur. The results indicated that the pictures did not all require the same cognitive abilities for their recognition. Nevertheless, some general effects of the cognitive abilities on slide recognition, which were independent of the particular picture, were also noticed. It was found that the ability to visualize (to transform the image of a spatial pattern into other visual arrangements) was negatively associated with early slide recognition, while Speed of Closure (the ability to unify an apparently disparate perceptual field into a single percept) was positively related to early recognition. It was also observed that visualizers tended to make fewer guesses about the blurred pictures than did nonvisualizers, while people who were high in Speed of Closure produced many initial hypotheses. It was found that the chances of recognizing early were greater for subjects who produced many initial hypotheses than for subjects who had few initial ideas.

These results cast doubt upon a theory of interference in visual recognition which states that early erroneous hypotheses inhibit recognition. It was suggested that hypothesis testing is not sequential and that the outcome of perceptual testing is a "confirmed-not confirmed" distinction, rather than an "accepted-rejected" one. The results were summarized in a post hoc computer simulation type of model which also incorporated the hypothesis that interference in perceptual recognition can be accounted

DD FORM 1 JAN 64 1473

Security Classification

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
1. Ambiguous Visual Stimulus 2. Perceptual Recognition 3. Cognitive Abilities 4. Visualization 5. Gestalt Completion Tests 6. Speed of Closure 7. Spatial Scanning						

INSTRUCTIONS

1. ORIGINATING ACTIVITY: Enter the name and address of the contractor, subcontractor, grantee, Department of Defense activity or other organization *(corporate author)* issuing the report.

2a. REPORT SECURITY CLASSIFICATION: Enter the overall security classification of the report. Indicate whether "Restricted Data" is included. Marking is to be in accordance with appropriate security regulations.

2b. GROUP: Automatic downgrading is specified in DoD Directive 5200.10 and Armed Forces Industrial Manual. Enter the group number. Also, when applicable, show that optional markings have been used for Group 3 and Group 4 as authorized.

3. REPORT TITLE: Enter the complete report title in all capital letters. Titles in all cases should be unclassified. If a meaningful title cannot be selected without classification, show title classification in all capitals in parenthesis immediately following the title.

4. DESCRIPTIVE NOTES: If appropriate, enter the type of report, e.g., interim, progress, summary, annual, or final. Give the inclusive dates when a specific reporting period is covered.

5. AUTHOR(S): Enter the name(s) of author(s) as shown on or in the report. Enter last name, first name, middle initial. If military, show rank and branch of service. The name of the principal author is an absolute minimum requirement.

6. REPORT DATE: Enter the date of the report as day, month, year; or month, year. If more than one date appears on the report, use date of publication.

7a. TOTAL NUMBER OF PAGES: The total page count should follow normal pagination procedures, i.e., enter the number of pages containing information.

7b. NUMBER OF REFERENCES: Enter the total number of references cited in the report.

8a. CONTRACT OR GRANT NUMBER: If appropriate, enter the applicable number of the contract or grant under which the report was written.

8b, 8c, & 8d. PROJECT NUMBER: Enter the appropriate military department identification, such as project number, subproject number, system numbers, task number, etc.

9a. ORIGINATOR'S REPORT NUMBER(S): Enter the official report number by which the document will be identified and controlled by the originating activity. This number must be unique to this report.

9b. OTHER REPORT NUMBER(S): If the report has been assigned any other report numbers *(either by the originator or by the sponsor)*, also enter this number(s).

10. AVAILABILITY/LIMITATION NOTICES: Enter any limitations on further dissemination of the report, other than those imposed by security classification, using standard statements such as:

(1) "Qualified requesters may obtain copies of this report from DDC."

(2) "Foreign announcement and dissemination of this report by DDC is not authorized."

(3) "U. S. Government agencies may obtain copies of this report directly from DDC. Other qualified DDC users shall request through ________________."

(4) "U. S. military agencies may obtain copies of this report directly from DDC. Other qualified users shall request through ________________."

(5) "All distribution of this report is controlled. Qualified DDC users shall request through ________________."

If the report has been furnished to the Office of Technical Services, Department of Commerce, for sale to the public, indicate this fact and enter the price, if known.

11. SUPPLEMENTARY NOTES: Use for additional explanatory notes.

12. SPONSORING MILITARY ACTIVITY: Enter the name of the departmental project office or laboratory sponsoring *(paying for)* the research and development. Include address.

13. ABSTRACT: Enter an abstract giving a brief and factual summary of the document indicative of the report, even though it may also appear elsewhere in the body of the technical report. If additional space is required, a continuation sheet shall be attached.

It is highly desirable that the abstract of classified reports be unclassified. Each paragraph of the abstract shall end with an indication of the military security classification of the information in the paragraph, represented as *(TS)*, *(S)*, *(C)*, or *(U)*.

There is no limitation on the length of the abstract. However, the suggested length is from 150 to 225 words.

14. KEY WORDS: Key words are technically meaningful terms or short phrases that characterize a report and may be used as index entries for cataloging the report. Key words must be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location, may be used as key words but will be followed by an indication of technical context. The assignment of links, roles, and weights is optional.

13. Abstract (Continuation)

for by the tendency for visualization to predominate over the formation and testing of hypotheses during conditions of extreme ambiguity or blur.

Finally, the status of Speed of Closure as a separate, unitary cognitive ability was questioned. On the basis of the great similarity between the relations of recognition point and Speed of Closure to the other variables employed in this study, it was suggested that tests for Speed of Closure may potentially involve the same interference effects which are observed in experiments in perceptual recognition.